Global Green Growth Institute

Case Study

Solar-Powered Irrigation Pumps in India — Capital Subsidy Policies and the Water-Energy Efficiency Nexus

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This case study is intended to serve as an example of policies and practices relevant to pursuing a green growth model of development. It describes activities and programs performed by organizations other than GGGI, and GGGI itself had no direct role in their development, adoption, or implementation.

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01 Summary

Page 1 – the big issue is that agricultural electricity is almost free and ground water remain unpriced. Para 1 of the summary needs to be clear on this.

As a country dominated by the agricultural sector, which employs about half the population, India has the largest irrigated area in the world. India's 26 million groundwater pumps, which mainly run on diesel or electricity, are an important part of the country's agricultural productivity. However, these water pumps have created various challenges to both farmers and the government. Electric pumps tend to be unreliable, diesel is a costly fuel for water pumping, and both types of pumps rely on approximately USD 6 billion per year in government subsidies which creates externality that distorts the true cost of production, and thus leads farmers tend to waste electricity and pumped water as there are no incentives to save both. Rain-fed farming or conventional pumps run by electricity and diesel have resulted in reduced yields, diminishing income for farmers, and thus have hampered livelihood improvements in rural India.

To address these challenges, the Government of India (GoI) has aggressively promoted the use of new solar pumping systems, mainly by working to reduce the high up-front costs that have been the biggest barrier to adoption by farmers. Under India's National Solar Mission program, the central and state governments support farmers not only by providing a capital cost subsidy on solar pump systems, but also by creating an enabling framework on their deployment by actively engaging key stakeholders. A credit-linked subsidy scheme also invites local financial institutions across the country to provide loans, reducing the subsidy burden on the government and making the system more affordable to farmers.

Different approaches have been adopted at the subnational level to address different groundwater and energy contexts. In water-abundant states in eastern India, like Bihar, a service-based delivery model with a capital subsidy scheme provides co-benefits for both farmers and equipment providers.

In water-scarce western states, like Gujarat, where water over-extraction is also a concern, a grid-connected buy-back scheme and solar cooperative model provides incentives for key stakeholders in the value chain to maximize water and energy efficiency.

The enabling environment created by the GoI, coupled with effective and innovative context-specific delivery models, has resulted in noteworthy initial successes. These have included environmental, economic and social benefits, emission reductions, reduced reliance on subsidies, increased agricultural output, development of new businesses, job creation, and improved income and livelihoods in rural areas. Although some challenges remain, these models offer potentially replicable strategies to support solar irrigation pumping systems in other countries. The GoI plans to begin exporting Indian-made solar irrigation pumps and provide technical assistance to other countries interested in promoting greener alternatives to irrigation.

Sectors in Focus

Water and Energy

Key Challenges

Addressing inefficiency in water and energy supply in rural India that hinders crop productivity, depletes groundwater, and diminishes farmers' livelihoods

Impacts

Environmental: Replacement of fossil-fuel pumps with solar-powered pumps contributes to environmental conservation by reducing CO2 emissions (25.3 million tons and 2.5 million tons from replacement of 1 million diesel pumps and 1 million electric pumps, respectively).

Social: Solar pump systems improve the farmers' standard of living by providing reliable, predictable, and affordable energy for irrigation. It also contributes to addressing health, education, and gender issues.

Economic: For government and the country as a whole, the economic impacts include subsidy savings on diesel and farm electricity, forex savings that can release current account deficit, agricultural output increase, and development of relevant industry that brings job creation. Farmers can enjoy increased income at a minimum cost, through enhanced crop productivity, higher-value crops, and multiple cropping cycles.

Keywords

Solar water pump, irrigation for agriculture, groundwater depletion, water cooperative, water as a service, pay-as-you-go, buy-back scheme

Geographic Coverage

Bihar and Gujarat, India

02 Context

Irrigation has become an important part of global agricultural production, consuming about 70% of global freshwater resources (FAO 2016). Reliable irrigation can increase crop yields by up to two to four times (Mehra 2015),[11] and is thus a key priority for both individual farmers and for meeting national development objectives. Solar-powered pumping systems are increasingly becoming a reliable, environmentally sustainable, and affordable alternative for irrigation to replace conventional diesel or electric pumps.

India relies heavily on agriculture. Although its contribution to India's GDP has been steadily declining as proportion of the overall economy (15% of GDP), agriculture continues to employ about 50% of the country's workforce (KPMG 2014). Irrigation is used in about 45% of India's cultivated area, while the rest relies on monsoon rain (Department of Agriculture and Cooperation, 2014). Thus, sound and expanded irrigation is critical for improving crop production and raising yields. For over 50 years until 2010 India ranked first with the largest irrigation area in the world (Renner 2012; FAO 2016).[2]

Currently, India has 26 million groundwater pump sets, which run mainly on electricity that is primarily generated in coal-fired power plants, or run by diesel generators (Pearson and Nagarajan 2014).[3] Irrigation pumps used in agriculture account for about 25% of India's total electricity use, consuming 85 million tons of coal annually, and 12% of India's total diesel consumption, more than 4 billion liters of diesel (Upadhyay 2014; and KPMG 2014).

Indian farmers and the national government both face several challenges with regard to irrigation. Electricity in India is provided at highly subsidized low tariffs, mostly at flat rates, and this has led to widespread adoption of inefficient pumps (Desai 2012). Farmers have little incentive to save either the electricity, which is either free or highly subsidized, or the water being pumped, resulting in wasting both. In locations with limited and unreliable access to the electric grid, farmers depend on high-cost diesel-fuel generators for water pumping. Reliance on electricity- and diesel-based water pumps has resulted in poor irrigation practices, with reduced yields, diminishing income for farmers, and hampered livelihoods in rural India. Irrigation woes have been further compounded by increasingly erratic rainfall patterns due to climate change that can damage crops and reduce yields.

The GoI spends roughly $6 billion annually for subsidies on groundwater pumps that run on diesel and electricity (Mehra 2015). This increases India's reliance on imported fossil fuels, adds fiscal burdens to the government, and contributes to strain on the environment.

For a country with plentiful sunlight but limited fossil-fuel resources, solar-powered pumping systems has emerged in India as a promising solution to meet the irrigation requirements of land holdings for small and marginal farmers. The dramatic fall in global photovoltaic (PV) prices and soaring diesel prices in recent years have helped further promote solar pumps for irrigation. Solar water pumps in general present significant benefits, including increased access to affordable irrigation, long equipment lifetimes, near zero operational costs, minimal attendance and maintenance, and reduced emissions.

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[1] More details on the potential of higher yields from irrigated agriculture can be found in the FAO report, available at ftp://ftp.fao.org/docrep/fao/005/y3918e/y3918e00.pdf, on page 16.
[2] China became the country with the largest irrigation area starting in 2010. As of 2014, India had 66.7 million ha in irrigated areas, following China with 69.4 million ha (FAO, 2016, http://www.fao.org/nr/water/aquastat/didyouknow/index3.stm)
[3] Around 69% (18 million pump sets) of groundwater pumps in India are grid-connected, while the rest 31% (8 million pumps) are run by diesel.

Since 1993, the Ministry of New and Renewable Energy (MNRE) has developed programs for deployment of solar water pumping systems for irrigation and drinking water across 29 states, aiming at commercializing solar water pumping systems by improving the enabling environment for delivery of the systems (GIZ 2013).

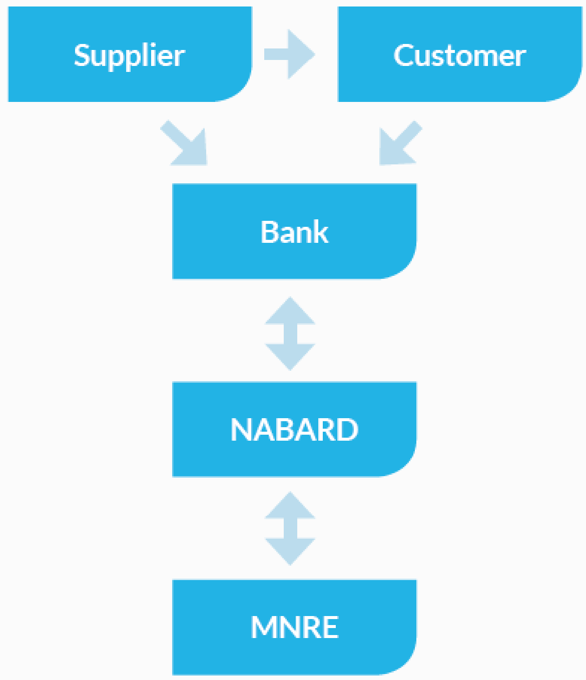
Nevertheless, the solar water pumping market has remained small and reached only a few states, primarily due to high up-front capital costs and low awareness among farmers. As of 2014, a total of 12,000 to 13,000 solar pumping systems have been installed in India (KPMG 2014).

03 Approach

In India, solar water pumps are primarily promoted through government subsidies. As the up-front cost of a solar pump is about ten times that of a conventional pump (KPMG 2014), capital subsidies and financing support have been critical. With the launch of the Jawaharlal Nehru National Solar Mission (JNNSM) in 2010, the MNRE solar water pumping program was integrated into the off-grid and decentralized component of JNNSM. Under JNNSM, state renewable development agencies have installed solar agriculture pumps largely through capital subsidies – 30% from MNRE and 30-60% from state governments[4] provided to farmers – while farmers pay the rest (Pullenkav 2013). The Indian Renewable Energy Development Agency (IREDA), State Nodal Agencies (SNAs), and private sector actors are also offering solar pumping support services. Buyers are free to procure systems from certified manufacturers, through state governments, or non-governmental organizations (NGOs). Key stakeholders interact in the value chain of solar irrigation pumps, as illustrated on the next page.

In 2014, the MNRE launched a new "credit-linked capital subsidy scheme" to replace conventional groundwater pumps with 30,000 more efficient solar irrigation pump sets per year and to enable farmers to reap additional income through higher cropping intensity (MNRE 2014). The process of bundling the subsidy with financing is implemented through a banking network, with the National Bank for Agriculture and Rural Development (NABARD) playing the role of the subsidy-channeling agency. Suppliers connect customers to banks and help submit subsidy and loan applications. Based on guidelines issued through the MNRE,[5] solar pumps eligible for capital subsidies range from USD 659 (INR 43,200) to USD 865 (INR 57,600) per horsepower (HP) pump set depending on the solar PV (SPV) system and capacity. Beneficiaries are invited to contribute a minimum margin of 20% of the total financial outlay (TFO), along with bank loans at normal banking interest rates, over a 10-year repayment period.

Credit-linked Capital Subsidy Scheme by MNRE (through NABARD)

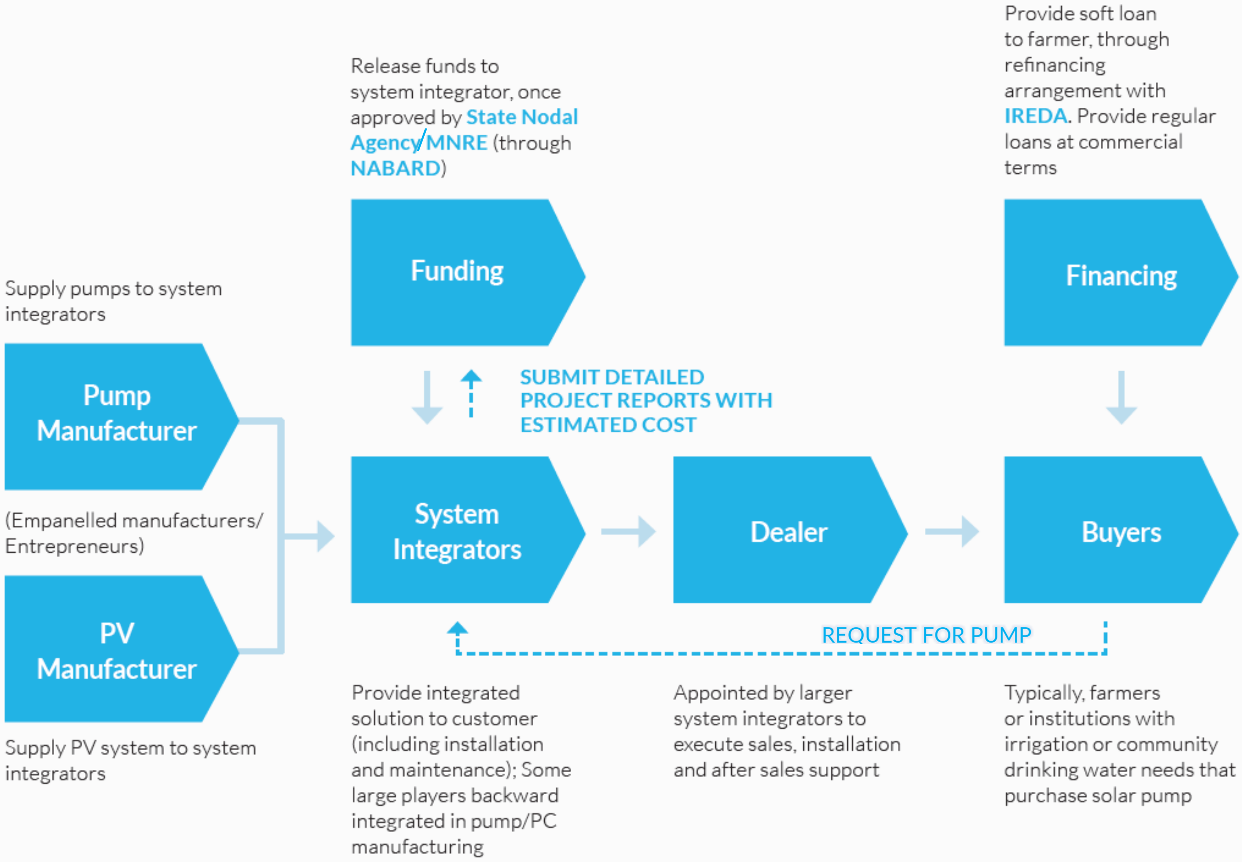


* Source: Paul, B.G. (2014). Government Policies on Solar Pumps.

[4] The State governments of Punjab, Gujarat, Rajasthan, Chhattisgarh, Uttar Pradesh, Maharashtra, Karnataka, Tamil Nadu, and Bihar have schemes to implement solar irrigation pumps subsidized with financial assistance available under the JNNSM and with their own budgets. Rashtriya Krishe Vikas Yojana 7 (RKVY) in Rajasthan and Bihar Saurkranti Sinchai Yojana (BSSY) in Bihar are schemes run by state governments (Kishore 2015, 23; GIZ 2013, 11).

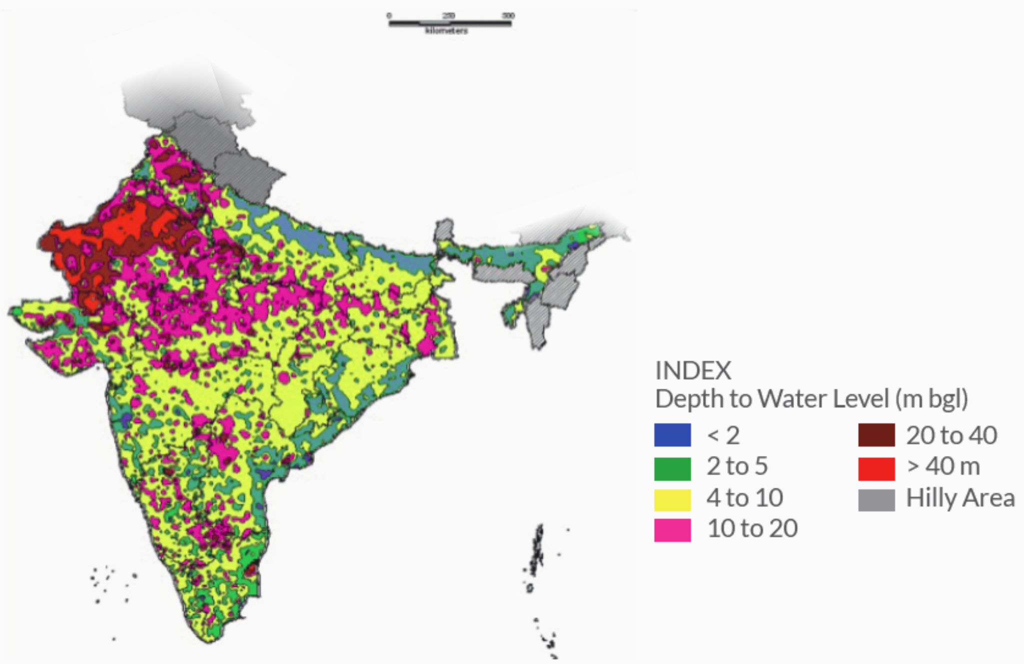
[5] Technical specifications include: indigenously produced modules, solar PV array capacity in the range of 200 Watt to 5KWp, and with a provision of tracking the sun, etc. Manufacturers/entrepreneurs empaneled by MNRE can only participate in the scheme. (MNRE 2014).

Overview of Key Stakeholders – Roles and Interactions in Solar Irrigation Publiing System Provision in India



* Source: Author's complementary descriptions added to the graphic of KPMG. (2014). Feasibility analysis for solar agricultural water pumps in India. Page 6, 18.

Depth to Water Level Map (Pre-Monsoon – 2011)



* Source: Pullenkav, T. (2013). Solar Water Pumping for Irrigation: Opportunities in Bihar, India

The MNRE has also established targets for the number of solar pumps installed for each state government, while encouraging individual banks to set goals for financing solar pumps, give priority to solar loans, and reduce collateral requirements (MNRE 2016). Progress under the scheme is monitored by NABARD and the MNRE on a regular basis.

In addition to the strong initiatives by the government, there are impressive examples of different approaches to promoting solar pump adoption in different locations as groundwater and energy availability varies greatly across the country India. Eastern India has abundant groundwater potential but lacks energy to pump it, while the western corridor suffers from groundwater depletion due to perverse electricity subsidies (Shah and Kishore 2012, Pullenkav 2013). As seen in the cases of Bihar (Box 1) and Gujarat (Box 2) "smart subsidy policies coupled with innovative and effective service delivery models have been used to address indirect risks and adverse effects from using solar water pumps. For areas with abundant groundwater (or even flood prone areas) such as Bihar, solar water pumps have helped create room in aquifers to absorb monsoon flood waters, thus mitigating flood risks (Sha and Kshore 2012). In such cases, an aggressive capital cost subsidy scheme combined with a pay-as-you-go model provides a preferable solution as farmers can avoid up-front costs and system performance risks, while system providers can get benefits from cost reduction associated with demand-based management. In water scarce areas like Gujarat, a buy-back scheme encourages farmers to sell surplus solar power to the grid in order to avoid excessive withdrawal and overexploitation of groundwater.

Box 1.
The Case of Bihar: Capital Subsidy Scheme Using the "Pay-as-you-go" Model

With high water tables, high solar radiation, limited reliable electricity, and conducive agriculture practices, Bihar has high potential for installing solar irrigation pumps[6] (GIZ, IGEN-RE, 2013, 20). The State government scheme "Bihar Saur Pump Yojana" is designed to provide additional revenue generation for farmers by making it possible to have more crop cycles per year. State government provides farmers with a 60% subsidy in addition to a 30% subsidy from the MNRE, requiring farmers to pay only 10% of the total costs of solar water pumps.

Recognizing the potential of solar irrigation pumping in Bihar, GIZ's Indo-German Energy Program (IGEN-RE) identified key barriers and challenges to overcome, including low awareness and financial affordability, poor maintenance support, lack of economically viable business models, and poor market environment (IGEN-RE 2013). To address these issues, the IGEN-RE undertook activities to create enabling market conditions. This included creating demand and improving supply chains by running technology demonstrations, awareness campaigns, and capacity building sessions for stakeholders across the entire value chain, including farmers, government officials, financial institutions, technicians, private companies, and pump operators.

Bihar has also adopted the innovative business model of 'water as a service,' also known as 'pay-as-you-go.' Under this model, the system provider (land donor of the tube well) would bear the capital costs and charge farmers a government-fixed irrigation service fee (ISF), based on serviced water. The Bihar Water Users' Association (WUA) (farmers' cooperative) manages irrigation, collects fees, and maintains the system, with support from a private company, Claro Ventures, for operation and maintenance of the solar pumps for the initial five years. Through this model, farmers don't have to pay up-front costs and avoid system performance risks, while system providers can enjoy greater benefits through optimal management of the solar pump as per water demand that can help to reduce costs (KPMG 2014, 19-20; Kishore et al. 2015, 4).

[6] According to an estimate by HWWI, Bihar has the potential for 11 million solar PV pumping systems (GIZ, IGEN-RE, 2013, 20).

Box 2.
The Case of Gujarat: Guaranteed Buy-Back Scheme with Cooperative Model

Once fully financed and installed, solar irrigation pumping systems have no marginal operational cost, and farmers often extract more water than they need. As a result, in water-scarce states like Punjab and Gujarat there have been rising concerns of increased groundwater depletion.

Recognizing this problem, the International Water Management Institute (IWMI) initiated a pilot project under the Solar Power as a Remunerative Crop (SPaRC) program in Gujarat's Anand District. The SPaRC provides farmers a guaranteed buy-back of surplus energy generated from the water pump solar panels to the power grid, with the help of Madhy Gujarat Vij Company Ltd (MGVCL), a local power distribution company (DISCOM). In one case, a solar water pump system with 8 kilowatt peak (kWp) allowed a farmer to sell surplus power at a rate of INR 5 per unit, earning the farmer USD 112 (INR 7,500) over four months in 2015. Had this solar energy been used to pump water instead, about 8 million liters of groundwater would have been unnecessarily extracted. A similar buy-back scheme in Gujarat can yield USD 900 (INR 60,000) in extra income for a one-hectare farmer with a 7.5 kW solar pump from the sale of surplus electricity to the grid (Shah et al. 2016). The scheme benefits the farmers by adding to their incomes and provides incentives to conserve groundwater (IWMI 2015; Express News Service 2015; IRENA 2016).

In an attempt to reduce high transaction costs in the buy-back scheme, in 2016 IWMI launched the Solar Pump Irrigators' Cooperative Enterprise (SPICE), which consisted of six farmers in Dhundi village in Gujarat. The pumps of Dhundi SPICE are connected to a mini-grid that will pool metered surplus power to sell to MGVCL at a single point, under a 25-year power purchase agreement (PPA). Under the PPA, the SPICE is entitled to an attractive feed-in-tariff. This model provides the farmers a risk-free, climate smart 'cash crop', while liberating the DISCOMs and state governments from farm power subsidies. This showcases a more effective and manageable solution to groundwater depletion (IWMI 2016; Shah et al. 2016).

04 Outcomes

Status of Solar Irrigation Pump Installation

Owing to the government's continuous efforts, India is now a world leader in solar water pump use, with about 62,000 pumps in operation across the country (Chandrasekaran 2016). The GoI's recent ambitious initiative brought installation of 31,472 pumps during 2015-2016, larger than the total number installed since the beginning of program (MNRE homepage, accessed on 29 Aug 2016). Of the total, about 14,000 pumps were sold under the MNRE's Solar Pumping Program for Irrigation and Drinking Water (Chandrasekaran 2016), about 17,000 pumps were installed by various State nodal agencies, and about 700 farmers have benefited from financial support through the national NABARD scheme during 2015-2016 (MNRE 2016).

Economic and Environmental Outcomes

Several studies indicate solar irrigation pumps now have a competitive advantage over diesel pumps, involving a total cost that is 64.2% of the 10-year life cycle cost of diesel water pumps, even without the benefits of the subsidy (GIZ 2013, 25). According to one study, the amount of time for a farmer replacing diesel pumps with solar pumps to break even is about 4.1 years with improved agricultural yield and 7 years without improved yield (KPMG 2014, 10).[7] Considering the opportunity cost of the waiting time for grid connections and enhanced yields through reliable solar power supply, farmers are better off by choosing solar pumps for irrigation over electric pumps in spite of higher net present value (NPV) expenses over 15 years (Agrawal and Jain 2015, 7-8).

In addition to the economic advantages of solar pumps, benefits to the government include reduced diesel consumption and associated subsidies, savings in foreign exchange for diesel imports, reduced electricity use, reduced CO2 emissions, and improved crop yields and energy access (KPMG 2014, 11; IRENA 2016, 12-13), as summarized in the table below.

Private Sector Development

The GoI has boosted India's solar pump industry not only by aggressively promoting solar PV pumping systems for domestic use, but also by inviting other countries to popularize solar water pumps from Indian manufacturers. Recently, the MNRE announced a pilot program to invite 15-20 countries to promote solar pump use, jointly with the International Solar Alliance (ISA), to export solar pumps (with credit lines where necessary), explain the benefits, and provide training on Indian-developed solar pump standards (Chandrasekaran 2016).

Increased potential economic opportunities coupled with the government promotion has helped expand the number of private sector actors offering solar pumping systems. Currently, there are more than 120 companies operating in India's solar water pump market (MNRE website; Chandrasekaran 2016).[8]

Social Impacts

Through improved access to water and energy, solar irrigation pumping has enabled poor (small and marginal) farmers to enhance productivity and crop intensity at minimum cost while providing a cleaner and greener option for irrigation. Farmers can now cultivate more crops annually, which brings more income, enhances crop resilience, improves food security, and alleviates poverty.

[7] Based on assumed reductions in solar pump price by 30%, increase in diesel price by 3% per year, and increase in crop prices by 3% per year.

[8] As of 22 August 2016, 126 companies were listed as certified suppliers under the NABARD solar water pump program.

Table 1. Summary of Benefits and Impacts of Replacing Conventional Pumps with Solar

Benefits from replacing 1 million diesel pumps with solar pumps		Impacts
Reduction of diesel use	9.4 billion liters of diesel use over life cycle of solar pumps	Environmental
Subsidy savings	USD 1.26 billion (INR 84 billion) in diesel subsidy savings[9] over life cycle of solar pumps	Economic
Emission reductions	25.3 million tons of CO_2 emission abatement over life cycle of solar pumps	Environmental
Foreign exchange savings and relief of current-account deficit	By reducing diesel imports, USD 300 million savings annually, USD 4.5 billion over pump life	Economic
Benefits from replacing 1 million electric pumps with solar pumps		**Impacts**
Reduction of electricity use	Up to 2,600 million units of electricity, to relieve the overburdened old power grid	Economic and Environmental
Subsidy savings	USD 450-525 million (INR 30-35 billion) savings in farm power subsidies[10]	Economic
Emission reductions	2.5 million tons of CO_2 emission abatement	Environmental
Benefits to agricultural output from installing 1 million solar pumps		**Impacts**
Improvement in crop yields[11]	10% increase in crop yields or USD 300 million (INR 20 billion) annually, USD 4.5 billion (INR 300 billion) over the pump lifetimes	Economic
Other impacts of solar pumps		
Boosting relevant industry	Development of solar pump market and technology advancement	Economic
Job creation	Creation of small businesses/employment across the value chain	Economic

The lack of access to reliable pumping solutions had previously hindered improvements to the livelihoods of farmers in India. The solar pump systems have helped address this challenge by providing reliable, predictable, and affordable energy for irrigation. Farmers who had previously used diesel pumps no longer have to travel long distances to obtain and transport diesel fuel, are more insulated from market fluctuations, and benefit from reduced air pollution and associated respiratory health risks resulting from diesel pump operation. Farmers who replaced grid-connected pumps with solar

Rain-fed irrigation areas also receive various social benefits from solar irrigation pumps, including gender benefits. Solar pumping improves the livelihoods of a large number of women who are engaged in labor-intensive rain-fed agriculture and time-consuming water-fetching activity (IRENA 2016, 14-16), and in the long run can contribute to increased opportunities for girls' education and more time for women to spend in other activities.

[9] The GoI estimated about USD 6 billion annual savings in power and diesel subsidies for replacing 26 million conventional pumps with solar pumps (Pearson and Nagarajan, 2014).
[10] Solarization of 20 million electric pumps can save USD 9.0-10.5 billion (INR 600-700 billion) in farm power subsidies (IWMI 2016, 1).
[11] Access to affordable irrigation from solar pumps resulted in a 9-10% increase in yields of the two main crops in Bihar, providing a bigger increase in farmers' income (Kishore et al. 2015, 20).

05 Lessons

India added more than half the country's total installation of solar pumps in 2015, mainly through subsidies from the MNRE (through NABARD) and state governments. A key lesson from India's approach to solar irrigation pumps is the critical role of strong government initiative. Under the National Solar Mission, the MNRE set targets and created an enabling policy and regulatory framework for deploying solar energy technologies including solar water pumping systems. By setting indicative technical specifications on the types and capacities of solar PV and pumps, the MNRE has helped catalyze development of new solar pump system technologies that have enabled further cost reductions and market development. Another success has been the collective efforts in awareness raising and capacity building activities involving a wide range of stakeholders including state government, the financial sector, private companies, and other key stakeholders. State governments developed context-specific delivery models with support from external partners, while the MNRE conducted monitoring installation progress and supported information sharing with the public.

However, there are several potential areas for further strengthening the program. Despite subsidies and loans supported under the credit-linked subsidy scheme, as of May 2016, only about 700 users had benefitted from the scheme across the country. Recently, the GoI put additional effort into making the scheme more inclusive by requesting that banks prioritize solar loans and reduce collateral requirements. High up-front costs and reluctance to accept new technologies are still seen as the main barriers to promoting solar pump systems, and the 20% up-front payment for solar pumps is still not affordable for many poor farmers. There are potential opportunities to develop better credit instruments and additional incentive mechanisms for financial institutions to provide financing support to farmers. A service-based 'pay-as-you-go' water cooperative model may offer a solution. Providing well-designed training and capacity building programs can also help farmers and bankers understand the financing process for solar pumping systems. While the buy-back scheme coupled with the community-driven cooperative model can help maximize both water and energy efficiency, a challenge still remains how to best reach the optimum level of guaranteed buy-back prices that are acceptable to both farmers and utilities.

Irrigation is a multi-sectoral area where several issues including water, energy, and agriculture are closely interconnected. Given this, a holistic or nexus approach helps to avoid any potential issues in one sector when addressing problems in another, which is critical to ensure sustainability for all related sectors. Solar-powered irrigation systems provide a solution for sustainable irrigation, by delivering the necessary volume of water in a timely manner, utilizing energy sources at reduced costs, increasing agricultural outputs, and mitigating environmental impacts.

India's approach to promoting solar water pumps can be replicated in other countries depending on availability of alternative energy sources, water supply and distribution conditions (boreholes, tube wells, informal distribution networks, etc.), cropping patterns (drip irrigation), and crop irrigation needs. For example, in Africa where boreholes serve as

typical water supply in rural areas, the cooperative model of ‘water as a service’ has the potential for replication. Those areas where grid connection is available can potentially establish solar pump cooperatives with buy-back schemes.

Success Factors

- Government's strong initiative with putting in place enabling policy and regulatory frameworks.
- Development of context-specific delivery models by state governments supported by the Central Government and/or external partners
- Collective efforts for raising awareness and undertaking capacity building, by GoI, state governments, NGOs, and international institutions.
- Market development of solar PV pumping system industry and associated technology development of solar pump system, resulting in further cost reductions.

Impact

Environmental

- Replacing fossil-fuel pumps to solar-powered pumps can lead to significant emission reductions (25.3 million tons of CO2 from replacing 1 million diesel pumps and 2.5 million tons of CO2 from replacing 1 million electric pumps).

Social

- The solar pump system improves the standard of living of farmers by providing reliable, predictable, and affordable energy for irrigation. It also contributes to addressing health, education, and gender issues.

Economic

- Government can benefit from saving on subsidy expenditures for diesel fuel and electricity, foreign exchange savings resulting from reduced diesel imports, improved crop yields and increased agricultural outputs, and development of relevant technology and industry, which in turn results in increased employment.
- Individual farmers can enjoy increased income at a minimum cost as a result of enhanced crop productivity, introduction of higher-value crops, and increased numbers of crop cycles.

Limitations and Challenges

- High up-front costs are not affordable to poor farmers, and better credit instruments are needed to help further reduce capital costs.
- Capital subsidy support can be reduced when financing support to farmers becomes available. However, additional incentive mechanisms are needed to encourage financial institutions to provide financing support to farmers
- Reluctance to accept new technologies is still a barrier to disseminating solar pump systems. Training and capacity building can help raise awareness among various stakeholders in the value chain.
- While the buy-back scheme could be an innovative and viable solution to solve both water and energy consumption problems, a key challenge is how to best reach the optimum level of guaranteed buy-back prices that are acceptable to both farmers and utilities.

Further Information

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